LATE PLEISTOCENE BRYOLOGICAL RELICTS IN WESTERN MASSACHUSETTS

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There is a considerable literature documenting the persistence in New England of high boreal to arctic taxa of flowering plants. The majority of such species today find suitable niches on alpine summits, as in the White Mountains, Mt. Katahdin, and, to a lesser extent, on Mt. Mansfield. However, there are isolated cases of persistence at lower elvations (e.g., *Saxifraga aizoön, S. aizoides,* and *S. oppositifolia* at Smuggler's Notch, Vt.; *S. oppositifolia* on cliff faces at Willoughby, Vt.). The assumption is that these populations represent relicts left behind in isolated stands as arctic and alpine taxa reinvaded recently deglaciated areas subsequent to the Wisconsin Glaciation. An opposite assumption, that these pockets represent recent invasions from far northern loci is much less likely; indeed, in view of the precarious status of many of these relict populations, it seems much more likely that the "persistence" theory is correct.

To date there is little literature dealing with persistence of arctic and alpine taxa of Bryophyta in New England, although we find a diversity of reports intercalated in the taxonomic literature. Perhaps the two most striking cases are *Scapania spitsbergensis,* an arctic species found in the United States only on the Knife-Edge of Mt. Katahdin (Schuster, 1974), and *Marsupella boeckii,* an alpine and arctic taxon found in eastern North America only in Greenland (Schuster & Damsholt, 1974) and on a headwall of the Davis Pond basin of Mt. Katahdin (Schuster, 1974). To my knowledge, there is no prior documented case of persistence of arctic-alpine and high boreal bryophyte taxa at low elevations anywhere in New England. The following case, thus, appears to be unique and deserves documentation, especially since the several small niches are today threatened by a proposed dam construction.

HIGH BOREAL AND ARCTIC-ALPINE HEPATICAE IN THE GREEN RIVER VALLEY

During the last twenty years I have botanized almost annually—usually several times each collecting season—on the east and

northeast facing slopes of the Green River valley, in Colrain, Massachsuetts. A brief description of the niches where "critical" species occur follows. Along a narrow dirt road, usually closely following the river, are a series of schistose rock exposures where basic to weakly basic seepage occurs during the entire growing season. The exposure of these ledges and cliffs is such that, apart from limited early morning sunlight, they are in shade the remainder of the day. There are many crevices, fissures, and undercuts where direct sunlight never penetrates. The total area of these "critical" loci is perhaps no more than 200–300 sq. ft., along about 3.5–4.5 miles of the Green River. Nowhere above the Colrain–Leyden bridge over the Green River do suitable loci occur; hence the taxa cited below all occur in the lower portions of the Green River valley. This fact is cited because it is crucial to the future of the following populations.

I do not have accurate microclimatological data at hand. Unfortunately there is no practical way to acquire such data since the stations where measurements would have to be taken all lie within 3–12 feet of the dirt road and no instruments would survive there for more than a day or two. However, during the past several years, I have had class field trips to the Green River gorge in early May, from ca. May 5–15. In the single most crucial site, where six "critical" taxa survive (*Lophozia gillmani, L. heterocolpos, L. bantriensis, Jungermannia cordifolia, Scapania gymnostomophila* and *Pellia megaspora*), ice hangs on a rock wall each year into May, and I have seen the one and only microhabitat of *Scapania gymnostomophila* ice-covered as late as May 15. There is near-by a spring where *Jungermannia cordifolia* and *Lophozia bantriensis* occur. The spring water temperature apparently never exceeds ca. 60–64° F. Indeed, the most critical niche probably does not occupy more than 30–40 sq. ft.; to this area three of the taxa are confined: *Scapania gymnostomophila* (present in two populations, possibly covering less than a square foot), *Jungermannia cordifolia* (in a single population around a spring; less than 5–6 sq. ft.), *Lophozia bantriensis* (a single population, under 1 sq. ft.).

These facts suggest that three out of seven of the taxa cited below occur today under absolutely marginal conditions; the *Jungermannia cordifolia* and *Lophozia bantriensis* are not known to occur anywhere else today in eastern United States. From this I would conclude that even minor environmental alteration, especially anything

done to even marginally elevate the temperature, to introduce more light, or to equalize the temperature, would probably prove lethal to these populations.

ANNOTATED LIST OF THE TAXA

1. **Jungermannia cordifolia** Hook. (*Solenostoma cordifolium* (Hook.) Steph.)

Found in constantly irrigated, spongy mats around a spring gushing from a rock cleft. In spite of the fact that a short pipe has been driven into the cleft and countless people stop there to sample the water, especially during the fishing season, the species persists, and the population does not seem to be declining.

Although there are several early reports from southern New England (Evans, 1904; Evans & Nichols, 1908; Frye & Clark, 1944), these are based on errors in determination (Schuster, 1969); apparently only two early reports of the species, from Waterville, N.H. and Hartland, Vt. (Schuster, 1969, p. 940), are correct, although a report from Round Mt. Lake, Maine, may be authentic. *Jungermannia cordifolia* has not been found in these areas in over 50 years. Thus the taxon is known in eastern United States at most from the former 2–3 stations which are considerably further to the north; it becomes much more frequent under alpine and low arctic to boreal conditions in Quebec, Nova Scotia, and Newfoundland (Schuster, 1969).

2. **Scapania gymnostomophila** Kaal.

The presence of this species, in two small populations each consisting of perhaps only 20–35 plants (others perhaps have been overlooked owing to the fact that the plants are small, creep amidst the moss *Gymnostomum,* and are often nearly hidden from view), is remarkable. *Scapania gymnostomophila* is a common species in the Arctic and High Arctic, extending northward to 82°32′ N. in Ellesmere I. (Schuster et al., 1959) and to 83° in north Greenland (Schuster, 1974); it is frequent in basic sites in west Greenland (Schuster & Damsholt, 1974). Southward it extends, as a rarity, to Percé (where it occurs in a deep chasm with *Saxifraga oppositifolia*), Quebec, Newfoundland (Schuster, 1974), the Bruce Peninsula in Ontario, Nova Scotia, and Maine (Round Mt. Lake, Franklin Co.), Vermont (Willoughby; Quechee Gulf, Hartford; Smuggler's Notch), northern New York (Ausable Chasm, Clinton Co.). In its southern

stations it is everywhere rare and local and occurs as small populations.

3. **Lophozia gillmani** (Aust.) Schust.

Although Steere (1937), reporting *Lophozia gillmani* from northern Michigan, characterized it as a Cordilleran species, the plant is basically high boreal and arctic-alpine, with rare and scattered loci south of the upper edges of the boreal forest; 90% of its range lies within the Tundra, and it occurs northward to northern Ellesmere Island at 82°31′ N. (Schuster et al., 1959), and to 82°12′ N. in northernmost Greenland (Schuster, 1969). Although remaining frequent as far south as northern and western Newfoundland, the Gaspé, and the Lake Superior region (Schuster, 1969), it becomes exceedingly rare in New England, where it is known from Maine (Round Mt. Lake, Franklin Co.), New Hampshire (Beaver Brook Falls, Colebrook; Lime Pond, Columbia), Vermont (Hartland; Quechee Gulf, Hartford; Smuggler's Notch, Mt. Mansfield; Willoughby). In Massachusetts it occurs in only two stations: the Green River, where it is frequent but scattered in areas with basic seepage along less than two miles of the river, and in the Bear River, Conway. Both Massachusetts stations are at low elevations; both are in loci where ice may persist late into the spring.

4. **Lophozia bantriensis** (Hook.) Steph.

This is a rather widespread species in Europe (where it extends from Spitsbergen south to the Alps and Pyrenees, but also into Siberia, at ca. 60° N.). Even though there are numerous stations cited from western boreal and arctic North America, it is rare in the east, where it is known from isolated stations in Greenland, Ellesmere Island, northern Quebec, northern Ontario, and Newfoundland; some of these reports are doubtful (Schuster, 1969, p. 389).

Lophozia bantriensis is closely allied to *L. gillmani,* which is paroicous. Plants of *Lophozia bantriensis* are typically larger, often sterile, and dioicous. On all three bases, the Green River population can only be referred to *L. bantriensis,* even though the superfically similar *L. gillmani* occurs in the same area (although never admixed).

5. **Lophozia heterocolpos** (Thed.) Howe

Although widespread in the Arctic, where it occurs northward to 82°26′ N. in Ellesmere I. (Schuster et al., 1959) and 83°06′ N. in

north Greenland (Schuster, 1969), this species occurs with some frequency southward into the boreal forest. In areas with mixed coniferous-deciduous forests it becomes rare, and in deciduous-forested areas, such as the Green River, it is very rare. It is known from several stations in Maine, northern Vermont, and northern New York (Schuster, 1969), but occurs southward as a disjunct into the Catskills and to Grandfather Mt. in North Carolina; there a small population has been found very near the summit, at over 5900 ft. In Massachusetts, the Green River gorge population is the only one known; it occurs in at least three small populations, none covering more than a square foot in area.

6. **Lophozia badensis** (G. ex G. & Rabenh.) Schiffn.

Although this species is the "least" arctic of the four *Lophozia* species here cited from the Green River, the last station is still the only one known for *L. badensis* in Massachusetts. The species occurs northward to 82°26′ N. in Ellesmere Island (Schuster et al., 1959) and to 82°42′ N. in north Greenland (Schuster, 1969) and, if infrequently, southward into northern New England (Beaver Brook Falls, Colebrook, New Hampshire; Quechee Gulf, Hartford, Vermont). In southern New England it is known from the Green River station cited above, and from Salisbury, Litchfield Co., Conn. (Evans, 1910). *Lophozia bantriensis* is also found as a disjunct in several of the deep gorges of the Finger Lakes area of Central New York (Schuster, 1949)—areas where such northern disjuncts as *Pinguicula vulgaris, Primula mistassinica,* and *Sedum roseum* occur; it recurs in the Smoky Mts. of Tennessee, and in Ohio.

7. **Pellia megaspora** Schust.

Of the species here cited, this is perhaps the most interesting. Since its phytogeography will be shortly dealt with in some detail in Schuster, Newton, and Krzakowa (1980), only the esentials are given here. The species is endemic to eastern North America. I know of isolated stations in Newfoundland, Cape Breton, Nova Scotia, the Gaspé, northern Michigan, northern Minnesota, Vermont, central New York (a single station in a deep gorge), and from the Green River gorge in Massachusetts. Basicaly it is a local, boreal species that is restricted to areas with constant basic seepage. It is assumed that *Pellia megaspora* survived the Pleistocene south of Massachusetts and has shown only limited ability to reinvade its former pre-Pleistocene range. The species is unisexual and lacks asexual

propagula; as the name suggests, it also produces very large spores (64–80 × 100–120 μ)—the largest spores of any hepatic from northern areas known to me. These spores, furthermore, are green and appear to show short duration of viability (a topic currently under investigation). Hence dispersibility appears to be limited by spore size, spore duration, and restriction of the plant to sheltered loci where strong winds are not likely to occur. The species is an ecological specialist strictly limited to cool or cold areas with basic seepage. Since it is unisexual, establishment of bisexual "centers" from which it could spread seems difficult to accomplish. In fact, of the 20-odd stations of this species I have seen in 35 years of active collecting, the Green River population is the only one known to me. It also is the only population I know which has both ♂ and ♀ plants, thus enabling the species to go through its life-cycle. Although impossible to document with any certainty, it is likely that the Green River plants represent, if not the only viable (bisexual) population, then one of only a few such populations of this rare species. (One should mention that the only near relative of this species, *P. endiviifolia,* is able freely to reproduce asexually by fragmenting systems of narrow, autumnally produced branches. Such a system of asexual reproduction does not occur in *P. megaspora.*)

PHYTOGEOGRAPHIC AND ECOLOGICAL CONCLUSIONS

The seven species cited above occur in the Green River gorge in their only Massachusetts station, with the exception of *L. gillmani,* which is known from a single additional station. Most of the taxa are far northern in range, and four occur well northward into the middle latitudes of Greenland. Of perhaps even more significance are these two facts: (1) The group of seven species cited represents by far the largest assemblage of high boreal to arctic-alpine species known from any lowland area in New England; (2) at no other station in Massachusetts does this ensemble of species occur. (Relevant are the facts that I have actively botanized in New England for 35 years, and for the last 21 years have resided in Massachusetts. Even though, possibly, future field work will result in discovery of one or the other of these species in one or two additional loci in the state, I very greatly doubt this. The combination of a very cool site plus constant basic seepage has not been seen at any other point in the state.)

Why the high concentration of "critical" taxa at this one site, from which no arctic-alpine flowering plants are known? The answer obviously lies in the fact that plants as small as the mosses and hepatics can occupy very small niches in which pockets of at least marginally suitable sites persist. As stated in Schuster (1958, p. 257):

> "Bryophytes are able to survive in small niches, or "pockets," because their size is so small that their distribution is, within limits, largely a factor of the microenvironment....For this reason we may expect Hepaticae (and mosses) to persist in small pockets where a suitable microenvironment persists, long after the general climate of the region has become very definitely 'inimical.' It would appear that, especially in the case of the 'boreal' relicts, the bryophytes can persist for a much longer period than the larger vascular plants which are more restricted by the macroenvironment."

From these facts one must also conclude that any alteration of the general environment—especially anything done that would increase the temperature even marginally—would wipe out such relict populations which today survive under precarious and perhaps marginal conditions. The proposed creation of a dam on the Green River would almost surely guarantee that the aforementioned taxa would be exterminated there and that six members of our flora would become extinct in Massachusetts. Even if the species were not physically drowned out, the creation of a considerable body of water would serve as enough of an influence on the temperature that this alone, in my opinion, would be almost enough in itself to guarantee the demise of these populations.

One final note: I have not systematically surveyed all possible niches in the Green River valley, and I have made a study of only the Hepaticae. Thus the aforementioned is a minimal list. There may still be additional relict taxa to be found, especially if the mosses are carefully searched for.

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